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Dissemination of DTD on the battlefield may lead to better strategic and tactical decisions

Until about World War I, there was little need to distribute Geospatial Information (GI) to individual soldiers. The slow rate of maneuver and extremely centralized command and control systems required that only senior leaders be aware of an Army operational area. Additionally, the low resolution and poor accuracy of early GI, usually hand-drawn maps/charts, meant that it was usually only suitable for operational and strategic planning. It had limited tactical uses.

This paradigm began to change in World War I and was seriously addressed in World War II. The advent of mechanized warfare and close indirect fire support required that GI be accessible to lower unit levels. This larger more fluid battlefield required that first echelon units be able to autonomously coordinate forces and achieve distant objectives.

This philosophy was continued during the Cold War. AirLand Battle Doctrine required that small unit leaders autonomously adapt to changing tactical situations and continue to follow the commander's intent. These expectations of small unit leaders operating in a fast-moving nonlinear area of operations required that they have an expanded knowledge of the area of operations. Fortunately, we were able to analyze our primary area of concern (Europe), and the reinstitution of Terrain Analysis Teams satisfied these operational needs.

Challenge

Today's situation makes the same GI demands worldwide. In most cases, we will not have the luxury of analyzing the area of operations ahead of time. Additionally, planning and preparation times will probably be short. Therefore, "on-the-shelf" GI that can be distributed quickly and then enhanced is needed. The National Imagery and Mapping Agency (NIMA) developed the Geospatial Information Infrastructure concept to satisfy the data availability requirement. A suite of terrain information data types will be prestocked for immediate use. This data suite, known as Foundation Data (FD), consists of precisely positioned feature information, elevation information, and imagery suitable for strategic, operational, and some tactical applications.

The fluid, nonlinear nature of operational areas, coupled with increased demands for GI, presents unique data dissemination challenges. The development of Force XXI doctrine and the Army After Next has greatly magnified the amount of data required at user echelons. The integration of Digital Topographic Data (DTD) onto Army systems to improve command and control capabilities, has magnified the dissemination challenge by introducing disparate formats, media, and scales to an already nonstandard situation.

New concepts and plans

The Training and Doctrine Command's (TRADOC) Program Integration Office – Terrain Data (TPIO-TD) at Fort Leonard Wood, Mo., is tackling this issue. In cooperation with numerous other developers and agencies, and assisted by the Topographic Engineering Center's Geospatial Information Division they have developed a concept and draft implementation plan for data dissemination.

The data concept embedded in this plan is based on three integrated stages: Initial data, Updated data, and Feedback. Initial data are data produced by national production assets. The composition of the data will depend on operational preparation time, but, will normally be composed of NIMA FD. FD consists of Foundation Feature Data (FFD), 5-meter Controlled-Image Base (CIB), Digital Terrain Elevation Data Level II and Digital Point Positioning Data Base, and will be a available for worldwide operations on short notice. Updated data will be enhanced information, or mission-specific data, originating from both users and national assets. Feedback originates from users to national assets for incorporation of selected onsite observations.

The following figure (Page2) shows the data flow concept for the First

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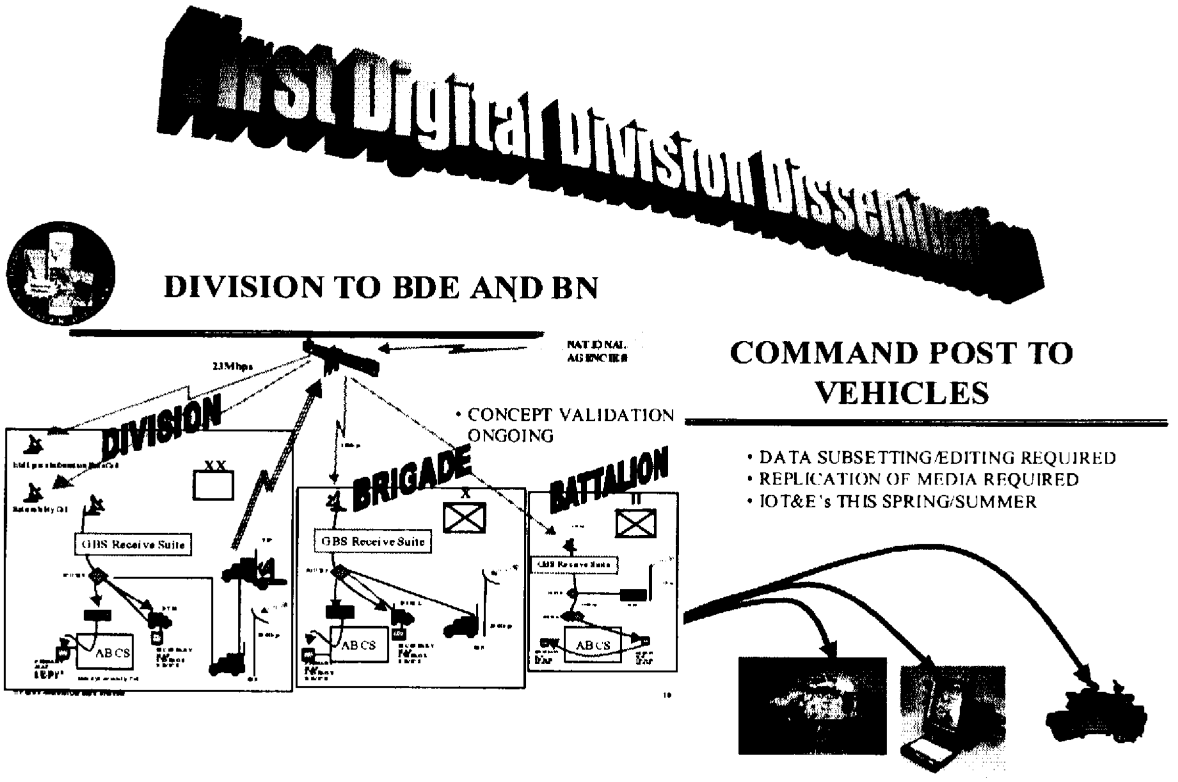
Dissemination, *continued from Page 1*

Digital Division (FDD). Following initial data transfer primarily by CD-ROM, updates are handled via Global Broadcast System from national agencies to the target echelon at division, brigade, or battalion. These data are then sent to a series of servers for final dissemination to users in the appropriate formats and compositions. As tactical communications will not support electronic dissemination below battalion, individual vehicles will be fed by data subsetting on appropriate media.

Numerous challenges still exist. Media standardization, communication capabilities, server integration to a Tactical Operations Center, and operational testing are a few of the issues that still need to be addressed and resolved. When these challenges have been met, the soldier will finally have reliable GI that will allow him to make sound strategic and tactical decisions. (Jeffrey Messmore and Rick Ramsey, U.S. Army Topographic Engineering Center, CETEC-GD-R, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6748, 703-428-6748, jmessmor@tec.army.mil or cramsey@tec.army.mil.)



Graphic courtesy of TPIO-TD.

GIDDS, a new demonstration tool, will enable unfamiliar computer users to understand DTD

How do you teach someone to read without any books? How do you describe the color red to a blind person? How do you demonstrate Digital Topographic Data (DTD) to someone unfamiliar with computers? Since its creation as the Concepts Analysis Division (later known as the Digital Concepts and Analysis Center), members of the Geospatial Information Division (GID) have been trying to answer the last question. In their attempts, they have created many different computer applications for demonstrating DTD. At the same time, to meet the needs of GID's customers, members developed software tools for exploiting data. All this creativity led to a new question. Is there a system that can run all this stuff?

User-friendly Interface

The answer to that question comes in the form of the Geospatial Information Development and Demonstration System (GIDDS). The GIDDS takes all those data demonstrations and exploitation tools and brings them together in a user-friendly interface. The GIDDS environment can be used to:

- Educate Army customers about DTD and the software used to exploit it.
- Evaluate DTD prototypes produced by the National Imagery and Mapping Agency, and other government organizations.
- Develop and test Topographic Engineering Center-sponsored reusable software applications.
- Evaluate the capabilities of Commercial-Off-The-Shelf and Government-Off-The-Shelf software applications.
- Provide crisis support.

Variety of formats

GIDDS provides interactive demonstrations on different data formats: raster [(ARC Digitized Raster Graphics (ADRG), Digital Terrain Elevation Data (DTED), Controlled-Image Base, and Compressed ADRG)], vector (Interim Terrain Data, Vector Map Levels 0-2, and Foundation Feature Data) and combinations using both. The system also provides access to ARC/INFO, ARCView, ERDAS IMAGINE and GID-developed GEOTRANS. GIDDS can not only demonstrate DTD but can create it as well.

For briefings where interactive demonstrations may be too involved or time-consuming, GIDDS has a slide show capability. Each interactive demonstration has this option. Additionally, there are slide shows on the GID Overview, Digital Topographic Data Standard Products, and Software Reuse and Development. GIDDS also has four QuickTime movie previews: Digital Map Backgrounds, DTD, DTED,

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Editor's note: *The "topo" logo or cube is symbolic of the spatial nature of Digital Topographic Data, which can be stored, manipulated, analyzed and displayed in 3-D.*

Contents

and Geospatial Information for the 21st Century Land Warrior.

Standard web technology

Gone are the days when smiling GIDers would show up at users' doors lugging hundreds of pounds of equipment for demonstrations. GIDDS uses standard Web technology, such as Java and common gateway interface scripting to perform its function. This means that with X-client software and a good Internet connection, GIDDS can be run remotely on a personal computer or laptop. A scale-downed version of GIDDS with only slide show capabilities has been created recently for use on personal computers without needing X-client software. The only software needed to view this version of GIDDS is a frames-compatible Internet browser (such as Netscape Navigator 3.x (or later) or Microsoft Internet Explorer 3.x (or later)). This version is available on CD-ROM.

Probably the greatest strength of GIDDS is its adaptability. As new data types and technologies become available, the GIDDS can grow and evolve to embrace them. Future Java programming may eliminate the need for X-client software altogether, creating a totally portable tool available to a wide variety of users.

For more information about GIDDS, contact Bill Ryder, U.S. Army Topographic Engineering Center, CETEC-GD-A, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6864, 703-428-6864 or wryder@tec.army.mil.

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The edge of the world: Revisiting Earth curvature concerns in terrain modeling

Most readers by now have seen computer-generated three-dimensional representations of terrain information through use of a Digital Elevation Model (DEM). DEMs are common data sets that have been generated at resolutions ranging from 1 to 100 meters for most of the world's land surface. DEMs also are used for modeling several terrain-based decision aids, the most prevalent of which is a Line-Of-Sight (LOS) calculation. The LOS algorithm is used to determine visibility between an observer and a target based on the intermediate profile derived from a DEM.

Spherical Modeling ("The Legacy Radius")

Because most DEMs are orthorectified to some datum, LOS calculations should take earth curvature into account rather than assuming a flat earth through a study region. This is done by subtracting the amount of vertical earth curvature for each sample point along a profile from the observer position.

In a current study of one such LOS model, it was discovered that even though the World Geodetic System 1984 (WGS 84) ellipsoid was the defined datum for the input data and resultant products, the earth curvature elevation compensation was based on a spherical earth model of unknown origin. The earth radius constant for the curvature computation is given as 6,371,392.9 meters, yet the semi-major axis of the WGS 84 ellipsoid is 6,378,137 meters and the semi-minor axis is given as 6,356,752 meters. Questions arose from this discrepancy, such as how the spherical earth radius was derived, how much earth curvature affects LOS calculations, and what is the magnitude of error introduced by basing earth curvature compensation on a different datum than that used for the DEM and other LOS spatial inputs.

The LOS model under study was massaged from legacy software code. With no documentation regarding its origin, the radius constant remains part of that legacy. Being expressed to the tenth of a meter implies that it was calculated from related values, but how this particular quantity was derived is still a matter of speculation. It is readily apparent that the constant was not derived by averaging the semi-major and semi-minor axes from combinations of familiar geodetic reference data. It was hypothesized that the constant represented a spheroid whose surface area or volume equaled that of a known ellipsoidal datum. Because each datum is defined by its semi-major (a) and semi-minor (b) axes, the formulae for surface area (S) and volume (V) of an oblate spheroid (an ellipsoid of rotation about the minor axis) were applied:

$$S = 2\pi \cdot a^2 + \pi \cdot \frac{b^2}{\varepsilon} \cdot \log_e \frac{1+\varepsilon}{1-\varepsilon}$$

and

$$V = \frac{4}{3}\pi \cdot a^2 b \quad \text{where eccentricity } \varepsilon = \sqrt{\frac{a^2 - b^2}{a^2}}.$$

Using these values for surface area and volume, the radii (R) for equivalent spheres were calculated from the formulae for surface area (S) and volume (V) of a sphere:

$$S = 4\pi \cdot R^2 \Rightarrow R = \sqrt{\frac{S}{4\pi}}$$

and

$$V = \frac{4}{3}\pi \cdot R^3 \Rightarrow R = \sqrt[3]{\frac{3V}{4\pi}}.$$

The semi-major and semi-minor axis values for several geodetic data were then used as input including WGS 1960, 1966, 1972 and 1984, GRS 1967 and 1980, Clarke 1866 and 1880, the International Ellipsoid, and Bessel's global datum of 1841, but none produced a match for the 6,371,392.90-meter radius constant. The origin of the fixed radius must, for now, remain a mystery.

In keeping with those early theorists who observed ships disappearing over the horizon, giving rise to the exploration of a round world, the vertical effect of earth curvature on LOS calculations increases with the distance between the observer and the target. Of interest to us is at what distance from the observer does this vertical effect become significant enough to be critical for LOS modeling reliability. For simplicity's sake, curvature along the equator is considered here. Using the WGS 84 equatorial radius (R=6,378,137 meters) for the right triangle in the illustration, the Pythagorean Theorem is used to determine the amount of earth curvature over a given horizontal distance. Solving for the length of the hypotenuse then subtracting R yields the amount of vertical drop due to curvature.

At a horizontal distance of 5 kilometers (km), the WGS 84 datum curves vertically all of 1.97 meters and 7.84 meters over a 10 km stretch. You have to go out 16 km before it bends over 20 meters. As the horizontal distance increases, the rate the datum curves downward increases. At 50 km the datum curves less than 200 meters vertically, yet at 100 km it drops more than 780 meters. A valid question at this point would be the significance of the consideration of this curvature in LOS predictions. The significance is not so much the absolute error of ignoring curvature at shorter distances, but the propagation of this error as the LOS is projected out. That 2-meter error at a distance of 5 km, will propagate to an error that can mask all objects less than 8

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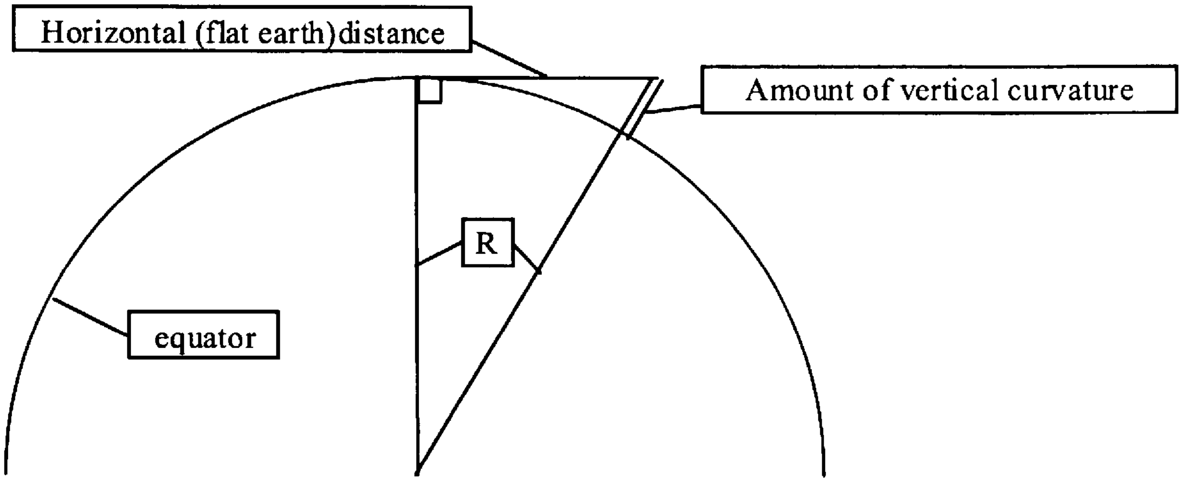

meters tall 20 km away. From a military perspective, many interesting and potentially lethal entities are less than 8 meters tall.

Ellipsoidal Modeling "A better fit"

Having established the importance of earth curvature computation for LOS modeling we are left to consider the amount of error introduced by using the spherical model to calculate elevation compensation rather than modeling to the actual datum being used, WGS 84 in this case. The first problem is calculating the radius of curvature for varying latitudes and view azimuths on an ellipsoid. The solution can be found in any decent geodesy text. This research consulted *Jordan's Handbook Of Geodesy, Vol. 3*, which was translated by Martha Carta, and published by the Army Map Service in 1962. Citing Euler's theorem, the radius of curvature (R) is computed for a given azimuth (α) at latitude (φ) as $\frac{1}{R} = \frac{\cos^2\alpha}{M} + \frac{\sin^2\alpha}{N}$ or $R = \frac{N}{1+\varepsilon'^2\cos^2\varphi\cos^2\alpha}$ which exploits the radius of curvature in the meridian defined as $M = \frac{a^2b^2}{\sqrt{(a^2\cos^2\varphi + b^2\sin^2\varphi)^3}}$, and the radius of curvature in the prime vertical $N = \frac{a}{\sqrt{1-\varepsilon^2\sin^2\varphi}}$. The term ε' refers to ellipsoidal eccentricity to the semi-minor axis and is defined $\varepsilon' = \sqrt{\frac{a^2-b^2}{b^2}}$. By substituting and reducing, a final expression was derived in terms of a and b, the semi-major and semi-minor constants of the WGS84 ellipsoid, the look azimuth α and the latitude φ. This new expression reads

$$R = \frac{\dfrac{a}{\sqrt{1-\left(\dfrac{a^2-b^2}{a^2}\right)\cdot\sin^2\varphi}}}{1+\left(\dfrac{a^2-b^2}{b^2}\right)\cdot\cos^2\varphi\cos^2\alpha}.$$

[Please note that the author is a cartographer with a modest math background. These equations were far from painless for him. If you have questions regarding the details leading to the solution for R, please consult a geodesist or at least a text on geodesy.]

Now able to solve for R at varying azimuths and latitudes, we can easily calculate the differences in the amount of curvature between the legacy sphere and the WGS 84 ellipsoid. The Δh table above shows some of these calculations.

Δh is calculated by subtracting the amount of curvature in the legacy sphere from that in the WGS 84 ellipsoid for the given parameters and is expressed in meters.

Latitude (φ) = 0°					
LOS distance (in km)	**5**	**10**	**16**	**50**	**100**
Δh for azimuth $\alpha = 0°$	0.0111	0.0445	0.1140	1.1134	4.4535
$\alpha = 45°$	0.0045	0.0181	0.0464	0.4530	1.8118
$\alpha = 90°$	-0.0021	-0.0083	-0.0212	-0.2074	-0.8298
Latitude (φ) = 20°					
$\alpha = 0°$	0.0088	0.0352	0.0903	0.8817	3.5266
$\alpha = 45°$	0.0030	0.0119	0.0306	0.2988	1.1949
$\alpha = 90°$	-0.0028	-0.0114	-0.0291	-0.2842	-1.1658
Latitude (φ) = 40°					
$\alpha = 0°$	0.0029	0.0118	0.0302	0.2954	1.1813
$\alpha = 45°$	-0.0009	-0.0037	-0.0094	-0.0916	-0.3667
$\alpha = 90°$	-0.0048	-0.0192	-0.0490	-0.4786	-1.9147
Latitude (φ) = 60°					
$\alpha = 0°$	-0.0037	-0.0148	-0.0380	-0.3706	-1.4828
$\alpha = 45°$	-0.0054	-0.0214	-0.0548	-0.5353	-2.1415
$\alpha = 90°$	-0.0070	-0.0280	-0.0719	-0.7000	-2.8003
Latitude (φ) = 80°					
$\alpha = 0°$	-0.0081	-0.0322	-0.0824	-0.8050	-3.2200
$\alpha = 45°$	-0.0083	-0.0330	-0.0845	-0.8248	-3.2994
$\alpha = 90°$	-0.0085	-0.0338	-0.0865	-0.8447	-3.3788

Intuitively, we know that for a given horizontal distance, the value Δh will be greater for the surface with the smaller radius of curvature; thus, negative values in the table above occur in those conditions when the legacy sphere's radius is smaller than the computed radius of curvature for the WGS 84 ellipsoid. This is always the case when the look azimuth is east-west because the minimum length for the radius of curvature is at the equator where it is equal to the semi-major axis of the ellipsoid. Worth noting are the values calculated over the higher latitudes, where the spheroid cannot account for the earth's polar flattening. The data reveals that this particular sphere approximates the ellipsoid fairly well. The average magnitude of error at 10 km is a hair more than 2 centimeters (cm), with a maximum error of 4.45 cm (looking north or south from the equator). If the sign of the error is considered for the averaging computation, the error value drops to under 1 cm.

Without doubt, no LOS calculations more than 2,000 meters should be made without compensating for earth curvature. As the accuracy of DEMs improve and the need to model/visualize terrain over even longer distances arises, modeling and simulation developers may have to consider the incorporation of a more rigorous computation for earth curvature compensation than the spherical model. For current LOS and visualization applications however, the errors associated with spherical computations for earth curvature compensation, when compared to the inherent vertical errors of available DEMs, are acceptable. (Michael Collins, U.S. Army Topographic Engineering Center, CETEC-TR-G, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6802, 703-428-6802 or collins@tec.army.mil.)

A New Frontier
The Army and Commercial Imagery

There's a new world dawning for the Army. It's the evolution of a revolution in how commercial satellite imagery is received, disseminated and exploited to support the military and non-military requirements.

The first step, albeit small, of this revolution started in 1990, when the Army's Commercial and Civil Imagery (C^2I) Office was formed at the Topographic Engineering Center (TEC) in Alexandria, Va. The office only had one person, no automation, no funding and little command support. At that time, the Army's imagery interests were primarily focused on classified national imagery provided by the Tactical Exploitation of National Capabilities (TENCAP) Program and limited airborne imagery from a variety of collectors. Unclassified satellite imagery was basically limited to the United States' Landsat satellite, a very wide-area, low spatial resolution system.

Over the last 8 years the C^2I program has matured, adding people, automation and command support. Now, the program is on the verge of a huge breakout in resources and capabilities that will provide timely assured receipt of commercial imagery in previously unheard-of timelines to military and civilian customers. Two of those capabilities, Eagle Vision II and SkyMedia will be discussed here.

Value to support operations

During Operations Desert Shield and Storm, imagery from the French SPOT commercial imagery satellite showed its value to support operations, intelligence and geospatial information systems. But, due to the time it took from the satellite's imaging of the target area until the processed product was delivered to the requesting unit, it did not meet operational timelines. But the potential was clearly demonstrated. The question was, 'how can we get the product to the user in time to support their requirements?'

The solution was to build a capability to provide assured receipt of that data. It sounded simple in concept, but implementation was a challenge. A number of possibilities were examined, but rejected. Finally a solution was reached – directly downlink data from the satellite to a mobile ground station that could be either co-located with the unit or located far enough forward that the data could be moved to the ultimate user electronically or via courier.

This requirement gained importance with the growing dependence of the U.S. military on commercial imagery satellites. The three most used sources of commercial imagery are SPOT, Landsat, and Radarsat. SPOT imagery is marketed in the United States by SICORP, in Reston, Va; Landsat was marketed by EOSAT until the merger with Space Imaging in 1996, in Thornton, Colo.; and Radarsat is now marketed by Space Imaging. A few years ago, 80 percent of the Department of Defense's (DOD) commercial imagery requirements to the EOSAT Corp. required the use of a foreign ground station for collection. Of that number, 90 percent of those requirements could not be met due to unacceptable delays in delivering data, improperly processed data, or a myriad of other problems. Additionally, the current political climate may preclude a foreign-owned commercial ground station from meeting United States commercial imagery requirements. A solution to these problems is to develop and field a mobile imagery ground station operated by U.S. forces to ensure the receipt and processing of that data.

Under the auspices of the DOD's Foreign Comparative Test program, a proposal was made to take French-based Matra Systeme's hardware and software, and install it in a transportable shelter. In July 1994, the system, named Eagle Vision I, was fielded to the U.S. Air Force, Europe at Ramstein Air Base, Germany. From the start, Eagle Vision I showed the value of assured receipt of the SPOT imagery product. Data could be counted on and there were no delays from collection until receipt. But the SPOT data had limitations. It was a wide-area collector, but not as wide a coverage area as some users needed. Also, it was limited to daylight and good weather. Could other systems be incorporated into Eagle Vision I to address these requirements?

Meeting requirements

The answer was to add new systems. To provide wider area coverage, and 7 band multispectral imagery, Landsat 5 was included in Eagle Vision I's sensor suite. Nine SPOT images are needed to equal the coverage area for one Landsat scene. The all-weather, day-night requirement was met by adding the Canadian Radarsat system. Collectively, the upgrade is known as Renaissance View. Now Eagle Vision I had a "full suite" of commercial imaging satellites, providing panchromatic, multispectral, and radar imagery in a constellation with good coverage and revisit characteristics. New commercial imagery collectors were planned for launch and Eagle Vision I was not easily transportable. Clearly, there was a need for a next-generation system.

Eagle Vision II is that system. It is building on the lessons learned with Eagle Vision I and will open a radically different era of commercial imagery usage for the U.S. Army, other military services, allied and coalition forces and selected U.S. governmental agencies. More importantly, Eagle Vision II will help the Army and other military services to answer three key questions crucial to the implementation of commercial imagery as a force enabler for commanders.

- First, and foremost, is the commercial imagery product, delivered by a direct downlink, of value to the supported unit or organization?
- Second, if the answer to the first question is "Yes", where is the best

place in the military architecture to implement this capability? For the Army, this probably means in either the Engineer or Military Intelligence Battlefield Operating System (BOS), but it could be in another BOS.

- Finally, once a decision on where Eagle Vision II or its capabilities best fit in, a determination must be made on how to best implement that force multiplier. Basically, should Eagle Vision II be incorporated into an existing or planned system, or should it be a stand-alone capability?

Eagle Vision II will be housed in a 34-foot trailer. It will receive data from a variety of commercial imaging satellites through a 5.4M-tracking antenna. Organic power and environmental support will allow it to be deployed virtually anywhere in the world, and operate with minimal support. Key to the design of Eagle Vision II, will be the ability to self-deploy all of its equipment on two U.S. Air Force C-130 transport aircraft or one C-141, C-5 or C-17. Eagle Vision II may also be transported on certain models (nose load) of commercial transport aircraft, as well. No infrastructure in terms of cranes, transporters etc. is needed. If the airplane can land, Eagle Vision II can roll off and be operational within hours of arrival.

New support to battlefield

The baseline sensor suite for Eagle Vision II consists of the French SPOT and Canadian Radarsat satellites. Planned for an upgrade to the baseline after its launch in early 1999 is the American Landsat 7. Additionally, Eagle Vision II plans on incorporating one to two of the high-resolution commercial imaging satellites, such as EarthWatch's QuickBird, Orbimage's Orbview 3 or Space Imaging's Ikonos. The objective of the Eagle Vision II baseline is to have at least five satellites, with a growth capability for up to ten systems. With the objective baseline capability, Eagle Vision II brings a new dimension in commercial imagery support to the battlefield. Unclassified 1-meter imagery that can be shared with allied and coalition forces with no security restrictions will now be available in minutes to hours from collection, versus days, weeks or months under the old architecture.

No special software or hardware

Another key aspect of Eagle Vision II is the imagery/data it produces and how it interfaces with information management systems. An inviolate precept of the Eagle Vision II program since inception has been to provide standard imagery/data that requires no special software or hardware for the supported entity to receive, process and/or disseminate. If they can handle the imagery provided today via courier or mail, then they will be able to handle Eagle Vision II data.

To accomplish this, Eagle Vision II will follow protocols, such as the DOD's National Imagery Transmission Format System (NITFS) and community-wide commercial standards. The focus for production is "soft-copy" data that can be manipulated or turned into maps or other graphic products. Additionally, Eagle Vision II will have a limited capability to produce "hard-copy" maps.

Flexibility for customers

Standardized communications interfaces are a second keystone capability. Eagle Vision II will simply hook up as a node for the supported organization's Local Area Network, either via a direct hookup or a dial-up connection. Flexibility in communications is a basic requirement, and Eagle Vision II will be able to operate under standard Ethernet data transfer rates, as well as Asynchronous Transfer Mode (ATM). To reach the satellite vendors and coordinate operations and imagery ordering, a location-independent technology, such as INMARSAT or Iridium is under consideration. No unique interfaces are required to hook into Eagle Vision II. This flexibility will allow Eagle Vision II to support DOD customers, as well as other government agencies such as the Federal Emergency Management Agency (FEMA) or State Department.

As a proof-of-concept system, Eagle Vision II will operate under the aegis of an Integrated Product Team (IPT). The IPT is composed of the National Reconnaissance Office (NRO), the Corps' TEC, the Army Space Program Office (ASPO), the Army Space Command (ARSPACE) and the Army's Training and Doctrine Command (TRADOC). The NRO is providing the basic funding and program management for Eagle Vision II. TEC is providing the systems garrison

An additional advantage of commercial imagery to support this scenario is that, since the product is unclassified, it can be widely shared among disparate elements as long as licensing requirements are met.

operating location and a mix of soldiers and Department of the Army civilians for system operation as needed and funded to support planning, sustainment, operation, and deployment. ASPO chairs the IPT, and is providing operations and maintenance funding. ARSPACE is providing the Officer-in-Charge and soldiers required to operate the system.

System testing

Under its current schedule, Eagle Vision II will arrive at TEC in late July 1999. After a period of testing and training, the NRO will accept the system from the contractor. TEC and ARSPACE operators will begin a series of exercises, demonstrations and real-world operations support lasting from 2-3 years. During this period, the aforementioned key questions will be addressed by TRADOC, and recommendations made to Headquarters, Department of the Army as to the future of Eagle Vision II and commercial imagery support to military operations. Applicability of Eagle Vision II to support other services' requirements will also be addressed, and data provided to them to assist in their evaluation of the value of assured receipt of commercial imagery to support operations.

One vision for Eagle Vision II would place systems in support of theater commanders in Europe and the Pacific, with a contingency system at a unit in the United States. A fourth "white" system would be located at TEC to support system development, civil disaster response and governmental agency requirements, while an Army "green" system will support CINCs, Joint Task Forces, and other military requirements.

A second complimentary series of "assured receipt" demonstrations as exemplified by Eagle Vision II will be conducted under the National Imagery and Mapping Agency (NIMA) auspices, during the 1999-2001 time frame. In response to congressional direction to address the issue of commercial imagery and its ability to support military operations, NIMA is sponsoring three commercial imagery dissemination demonstrations. NIMA's goal is to provide commercial satellite imagery to users within 24 hours of collection. To address options as to how to meet this goal, these demonstrations will be conducted in Europe, the Pacific, and Hawaii.

Various demo sites

The European demonstration will use the Joint Broadcast System (JBS) and Global Broadcast System (GBS) to transmit imagery from the NIMA/Defense Intelligence Agency's Commercial Satellite Imagery Library (CSIL) to selected units in the European theater of operations. The Pacific demonstration will use GBS to support dissemination of commercial satellite imagery from the CSIL to selected sites in the Pacific.

Since the GBS capability will not be available in the U.S. and Hawaii during the period of the European and Pacific demonstrations, an alternative was needed to find a timely means for providing commercial satellite imagery to units "stateside." After a review of potential solutions, NIMA chose the SkyMedia suite of equipment to support units in the continental U.S. and Hawaii.

SkyMedia will provide a "smart broadcast" to 34 sites, using the Telstar-4 satellite. This will provide 3-13Mb/sec of dedicated bandwidth to support the demonstration. At the receiving sites, a 1.2M antenna (larger in Hawaii) will provide an easily installable, minimal footprint that can be deployed to field locations if desired. NIMA also is providing a Windows NT-based workstation to serve as the receive station and server for imagery pulled in with SkyMedia. Sites will request selected images from the CSIL via phone, fax or the Internet. The CSIL will then broadcast those images on a first-in, first-out priority to only those site(s) requesting the product. The continental U.S. and Hawaii limitation for SkyMedia is a recognized limitation, but is not considered a significant impediment to future operations, as the European and Pacific GBS capabilities should be in place by that time frame.

Army sites will include Forts Bragg, Hood, Campbell, Drum, Stewart, Lewis, Shafter and TEC. The TEC site will be the first site fielded, and will serve as a testing and demonstration location, as well as being a reserve system that can be deployed to contingency locations as required. Air Force sites include Colorado Springs, Offutt Air Force Base, Hurlburt Field, Langley Air Force Base, Beale Air Force Base and Scott Air Force Base. Navy and Marine Corps sites include Camp Pendleton, Naval Air Station Fallon, San Diego, Dahlgren Va. and Stennis, Miss. Additional locations include Headquarters Central Command (CENTCOM) and Southern Command (SOUTHCOM). Thirty-four systems are scheduled for fielding during the final quarter of 1998 and the first quarter of 1999.

Other scenarios possible

The SkyMedia demonstration is scheduled to run for at least 1 year after completion of the installation of the systems at the sites. The demonstration may be extended, or possibly turned into an operational system, if there is no other capability available that can equal SkyMedia in dissemination rates, operational efficiency and cost. SkyMedia, along with Eagle Vision II, can support the military, as well as the civil sector. A civilian scenario would place Eagle Vision II operating from its garrison location at TEC collecting commercial imagery prior to and after a hurricane struck the southeastern coast of the United States. With an expected range of 2,200 kilometers (km) or more for collection, Eagle Vision II should be able to reach as far south as Cuba and as far west as the eastern portion of Texas from Alexandria, Va. (TEC).

Eagle Vision II would process that data, and then transmit it via landline to the CSIL. The CSIL would then transmit that imagery to selected SkyMedia sites, such as HQ SOUTHCOM in Miami, Fort Stewart, Ga., Fort Bragg, N.C. and Langley Air Force Base, Va. That data would be available to those military elements or

(Continued on Page 12.)

Making sense of government standards for digital imagery and related products

The defense and intelligence communities use the National Imagery Transmission Format Standard (NITFS) for raster data transmission. NATO, the International Standards Organization (ISO) and the civilain part of government (represented by the Federal Geographic Data Committee (FGDC)) are developing related standards.

A picture can be stored as raster files, a grid of values that represent the color of part of the picture. Overhead imagery and scanned maps are often stored as raster files.

The commercial world has its own standards, and these commercial standards are generally very simple. The government standards discussed here are cumbersome because they use profiles and extensions. Let me explain what these are.

A profile is a format that conforms to a standard, but has extra rules. A broad standard can have a profile for each of several user communities. In a sense, Controlled-Image Base (CIB) and Compressed Arc Digitized Raster Graphics (CADRG) are profiles of Raster Product Format (RPF) because both CIB and CADRG data conform to the RPF standard. A profile may have more rules (for example, what types of data can fill a field) and may omit part of the format, so a profile of a standard can be longer or shorter than the standard itself.

An extension is a trick used to create a file that is technically standard but practically nonstandard. An extension is used to add nonstandard data to a file. For example, if the Vector Product Format (VPF) standard had a Digital Terrain Elevation Data (DTED) extension (it doesn't), I could send VPF and DTED data together as VPF data. Some VPF readers would be able to read DTED, and the rest would just read the VPF data and ignore the DTED. Of course, the DTED-capable readers would cost a lot more to make.

How are NITFS, NSIF and BIIF related?

NITFS: The Department of Defense (DOD) uses the NITFS for image transmission. NITFS is versatile, supporting large images, insets, color images, and Joint Photographic Experts Group (JPEG) compression. A NITFS file can include text, Computer Graphics Metafile (CGM) and Tactical Communications Protocol 2TACO2 data. DOD released a baseline version of NITFS in 1989, version 2.0 of NITFS in 1993, and version 2.1 of NITFS in October 1998.

NISF: NATO now uses NATO Secondary Image Format (NSIF) for raster data transmission. NSIF is almost the same as NITFS 2.1, so an NSIF reader and an NITF reader will be more or less the same thing.

BIIF: ISO has approved and published the Basic Imagery Interchange Format (BIIF) standard. BIIF will be a loose standard. BIIF profiles will include NSIF, NITFS, JPEG, TACO 2, Vector Quantization (VQ), Open Skies and Spatial Data Transfer Standard (SDTS) (more on SDTS later). All these formats will be BIIF-compliant, because BIIF specifies field length, but does not say much about what goes in a particular field. The profiles listed above are more rigid.

How are NITF and RPF related?

Government standards like NITFS are huge because they try to accommodate all sorts of data. For example, the original NITFS did not include RPF data. The National Imagery and Mapping Agency (NIMA) uses RPF to distribute raster map data (CADRG) and unclassified image data (CIB). RPF users didn't want to give up their format, but the NITFS people didn't want to give up the idea of a single standard. The solution was to expand NITFS to include RPF. This expansion brought VQ compression, pad (blank) pixels, and some extensions called Tagged Record Extensions (TREs) into the NITFS. This means that RPF data can be stored using RPF or NITF.

RPF data are stored in frame files, which fit together like tiles. A table of contents file stores the location of each frame file. Each frame file is itself a complete NITF 2.0 (not 2.1) file. The raster data are stored in TREs, and each of these TREs is an NITF file. The table of contents file also is in a TRE, but a different TRE. The reader uses this table of contents to reconstruct the image. The problem is that NITFS 2.0 is becoming obsolete.

NITFS 2.0 is not 2000-compliant, but NITFS 2.1 is. However, there is a marginal fix for the 2000 problem. New RPF and NITF 2.0 readers will assume that years from 51 to 99 are in the 20th century and that years from 00 to 50 are in the 21st. The reason that this fix is only marginal is that it will fail when dealing with years before 1951.

Another reason that NITFS 2.0 is becoming obsolete is that an executive order mandates changes to the storage of security data that make NITF 2.0 unusable.

Because of these obsolescence problems and because of the overhead required for NIMA to maintain both the RPF standard and the NITFS, the RPF standard will eventually be phased out. However, data very similar to RPF will continue to be produced as NITF.

After the RPF standard disappears, NITFS 2.1 will continue to accommodate RPF (because it will have the appropriate TREs) for several years, but there is no consensus on what "several" means. Some NITF readers will be able to read these TREs, and so also will be RPF readers. However, at this point we will call both the NITF and RPF data NITF. If at some point the TREs are discontinued, NIMA will produce data in NITF, and the Army will need to build or buy NITF readers.

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What is SRPBE?

Most civilian federal agencies transmit geographic information using SDTS. SDTS is a loose standard (like BIIF), so people use profiles of SDTS rather than SDTS. These profiles are organized by data type, such as raster and vector. This makes them different than BIIF profiles, which are organized by function. For example, there is a BIIF profile that holds geographic information and another that holds scanned fingerprint data. The FGDC is developing the SDTS Raster Profile with BIIF Extension (SSDTS Raster Profile with BIIF Extension) (SRPBE). There are a number of ways to describe the SRPBE.

A BIIF Profile: The SRPBE will be a geographic information BIIF profile for raster data. In other words, there will be BIIF data somewhere inside the SRPBE file.

An NITFS/NSIF Profile: The SRPBE will be a NITFS profile or an NSIF profile because SRPBE only includes those parts of BIIF that are present in NITFS and NSIF. This means that the BIIF extension part of the SRPBE can also be viewed as NITF or NSIF data.

An SDTS Profile: The SRPBE is a raster profile of the SDTS.

A wrapper: The SRPBE is a way to package an NITF, NSIF, or BIIF file so that it looks like an SDTS file from the outside. But even though the SRPBE looks like an SDTS file on the outside, an SDTS reader won't be able to read it at all, because it looks like a BIIF file on the outside. A BIIF, NSIF, or NITFS reader won't read it unless the reader has been built specifically to read SRPBE. Only a SDTS reader built for SRPBE will be able to read it; the reader must be able to read both the wrapper and the data that is wrapped.

Here are some ways that an SRPBE is more like SDTS than BIIF.

- SRPBE can include a big image and an inset image. For example, an image of Fairfax County, Va., could have an inset of the airport. SRPBE readers cannot see where the inset image fits in the main image, because SRPBE does not store the location of secondary images relative to the main image coordinates. NITF readers can do this, but SDTS readers cannot.
- SRPBE can include SDTS data, such as Digital Elevation Model (DEM) and Digital Line Graph (DLG).
- SRPBE readers (like SDTS readers) can decompress using run length encoding and JPEG compression. BIIF users can use whatever compression they choose, although the NITFS includes JPEG compression. (Daniel Sprecht, U.S. Army Topographic Engineering Center, CETEC-GD-A, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6761, 703-428-6761 or daniel.l.specht@usace.army.mil.)

The Army, *continued from Page 10*

it could be passed on to the U.S. Army Corps of Engineer District(s) responsible for that area, or provided to FEMA. An additional advantage of commercial imagery to support this scenario is that, since the product is unclassified, it can be widely shared among disparate elements as long as licensing requirements are met. A copy of a print can be given to a bulldozer operator repairing a levee. Another can go to the power company to help them plot disaster recovery options. A third could go to the American Red Cross to locate potential shelter sites.

A military operations scenario could have Eagle Vision II deployed to a forward operating location within 2,200 km of the target area. Imagery from one of the commercial systems would be downlinked to Eagle Vision II for initial processing to the level requested by the supported command. The data could be moved to a GBS injection node for transmission to other GBS sites or back to the CSIL for transmission via SkyMedia to units preparing for deployment from the U.S. to the crisis area. When the unit(s) deploy to the area, Eagle Vision II would receive a direct downlink of the required commercial imagery, and then provide it to the command for use in geospatial information systems, intelligence analysis or mission rehearsal planning.

The radical increase in capability and options provided by Eagle Vision II and Sky Media present a new frontier in the employment of commercial imagery to support military and non-DOD operations. Where previously the C²I Program relied on a long, occasionally unreliable architecture to support its customers, these new systems will provide unparalleled capabilities, flexibility and quality of product to support Army, DOD and civilian agencies' requirements for commercial and civil satellite imagery. The imagery isn't free, and NIMA and the Army are still developing funding strategies, but the potential this data brings adds a new dimension to battlefield visualization, intelligence support, mission planning and disaster relief. (Mary Pat Santoro, U.S. Army Topographic Engineering Center, CETEC-GD-S, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6909, 703-428-6909 or msanto@tec.army.mil.)

GIS Corner

Beyond the paper map . . .

The Captain yawned and lumbered into the conference room. After 20 years on the force, the weekly briefing began to lose its luster. He wanted to avoid dozing off during the droning talk and map review . . . but it was hard. Columbo was OK, but each week he would drag out his pointer, move to the map, and summarize the various incidents. Hmm.

Suddenly, the lights went out. Columbo sipped his coffee. The lights dimmed and music played softly in the background. Instead of seeing the paper map on a briefing board, the Captain saw an image of a map projected on the wall. Different maps appeared one after another. Critical features on the maps were connected to photographs, videos, and audio narration as patterns of crime were revealed. This was nice . . . very nice, but the Captain had seen slick canned presentations before.

The Captain asked a question about timing of crimes, hoping to see Columbo sweat. Instead, Columbo had already created a map of crimes committed between 0000 and 0600 earlier the same day. He also produced time-lapse movies showing crime over the past week by hour and crimes between 0000 and 0600 daily over the past year. One area seemed particularly hard hit in February and March. Columbo finished up with a map showing the current positions of all active units . . . and the units actually moved, while the map was displayed.

The Captain shook his head and simply said, 'Wow!'

From Columbo Meets Hollywood

Introduction

As Columbo showed the Captain, maps have come a long way in the past few years, particularly computer-generated maps. Paper maps will not disappear any time soon, because they are portable, packed with information, and have a printing resolution that will be unmatched by computers for years to come. But, paper maps have several disadvantages that are now just being addressed through new and innovative computer-based displays.

The primary problem with paper maps is that they are static displays. The mapmaker decides everything that will go on the map before it is printed. You cannot add, delete, or modify features without defacing the map. If you want to only look at some of the information, for instance, you must search through all the other details. In addition, it is very difficult to show changes over time and impossible to show real-time information. These limitations are being overcome as we move beyond the paper map, to the next generation of map displays, which are interactive and/or dynamic.

Interactive Maps

Interactive maps allow users to change the content and presentation of the map data as it is being viewed. At a basic level, this type of map gives users the capability to select the features to be viewed, modify their symbolization, as well as pan and zoom around the data. More sophisticated options include displaying data in different map projections, creating scale-sensitive features that turn themselves on or off depending on the map scale, and linking to other multimedia data, such as photographs, sound, or text.

Interactive maps challenge our basic ideas of what is a map. Paper maps are tangible things, which exist as an object and have an unchangeable appearance. Interactive maps exist in the computer and have an infinite number of forms, which are defined and modified by the map viewer. There is no longer a single product, but instead we have data, tools to view the data, and user-controlled views of the data. Unless a print is made of a display, it is ephemeral and may never be seen again.

Mapping packages, like MapInfo, Maptitude, Geomedia, and ArcView bring interactive mapping to the desktop, but they are still somewhat costly and require training to operate effectively. With the expansion of the World Wide Web, interactive maps, with very simple interfaces, are now widely and freely available to the general public.

Dynamic Maps

Dynamic maps show the movement and/or changes of geographic phenomena. They fall into two general classes, real-time maps and animated maps. Real-time maps show changes as they are happening, while animated maps are produced prior to being displayed.

Real Time

Real-time maps require a sensor, a map display, and a communications link between the sensor and map display. The sensor provides the information that is displayed on the map. The sensor could display the location of a feature and/or any other measurable characteristic such as temperature, humidity, precipitation, traffic count, etc.

Real-time maps were not possible with static paper map technology, because of the lag between map production, map printing, and map distribution. With the advent of networked computers and improved communications, it is possible to collect data and display it instantaneously. Examples of real-time maps include traffic maps, linked to traffic counters and video cameras; weather radar images; and vehicle fleet tracking maps.

Animated Maps

Animated maps are movies showing changes in geographic phenomena. Unlike real-time displays, they are produced prior to being viewed. Animated maps are particularly well suited to showing changes over time, such as changes in weather patterns, movements of troops, dispersion of oil spills, etc. They can just as easily show historical or planned events. Although it is not well known, animated maps are not limited to showing changes in time. Non-temporal animations are a powerful tool in scientific visualization, where knowledge may be gained by viewing data by other variables, such as area, population, temperature, etc. For example, an animation highlighting countries from smallest to largest population may reveal geographic patterns that are difficult to extract from a static paper map or a table of data.

The Future

With interactive and dynamic maps, we are just beginning to tap the potential for computer-based mapping. Until recently, most map research and development was directed toward using the computer to replicate static paper maps. Interactive and dynamic maps are finally beginning to move users beyond the limitations of paper products. We are on the frontier of a new technology, as inexpensive tools for creating maps are becoming available. As these tools become accepted, understood, and exploited, maps will move to a higher level of use and visualization.

In the next GIS Corner, we will look at other advances in map display technology, focusing on the three-dimensional display of data. (Douglas R. Caldwell, U.S. Army Topographic Engineering Center, CETEC-TR-G, 7701 Telegraph Road, Alexandria, VA 22315-3864, DSN 328-6802, 703-428-6802) or caldwell@tec.army.mil.)

GIS Tips

Books

Peterson, Michael P. (1995). *Interactive and Animated Cartography*. Englewood Cliffs, N.J.: Prentice Hall.

Web Sites

Web GIS and Interactive Mapping Sites
http://www.lib.berkeley.edu/UCBGIS/intergis.html

Web Mapping Hands-On Workshop (Static, Dynamic, and Animated Mapping)
http://www.geog.gla.ac.uk/workshop/Workshop.htm

Interactive and Animated Cartography
http://maps.unomaha.edu/books/IACart/book.html#WEB

GID Points of Contact
(Commercial 703-428-XXXX

Mission Areas	POC Name	DSN 328-XXXX
INFORMATION REQUIREMENTS AND DESIGN BRANCH		
Mission-Specific Data Set Definition	Debra Kabinier	6758
Joint Mapping Tool Kit (JMTK) Technical Evaluation	Denise Hovanec	6759
Command, Control, Communications and Intelligence	Jim Allen	9173
Modeling/Simulation and Training	David Lee	9173
Army Modeling Improvement Program Studies	Louis Fatale	6760
Digital Data Dissemination Issues	Rick Ramsey	6784
GID Software and Data Requirements Database	Katherine Ebersole	9173
Geodesy/Datum Transformations	James Ackeret	9173
High-Resolution Elevation Data (DTED Levels 3-5)	James Ackeret/Louis Fatale	9173/6760
Prototype Evaluations	Jeff Messmore	6748
Digital Topographic Data Availability	Katherine Ebersole	9173
User Education	Debra Kabinier	6758
Force XXI Geospatial Information Issues	Rick Ramsey	6784
GI&S Community Technical Exchange Meeting	Louis Fatale	6760
Embedded Weapons Mapping Systems	Jim Allen	9173
Terrain Analysis Issues	Louis Fatale	6760
INFORMATION APPLICATIONS AND TECHNOLOGIES BRANCH		
MC&G Software Reuse	Gail Collins	6505
Controlled-Image Base (CIB)	Dan Specht	6505
National Imagery Transmission Format (NITF)	Dan Specht	6505
Raster Product Format (RPF)	Dan Specht	6505
Coordinate Conversion and Datum Transformation	Dan Specht	6505
GEOTRANS	Dan Specht	6505
TEC-SR-7	Dan Specht	6505
Digital Geographic Information Exchange Standard (DIGEST)	Kevin Backe	6505
Digital Point Positioning Data Base (DPPDB)	Kevin Backe	6505
Federal Geographic Data Committee (FGDC) Feature Registry	Kevin Backe	6505
Spatial Data Transfer Standard (SDTS)	Kevin Backe	6505
Geospatial Information Development and Demonstration System (GIDDS)	Bill Ryder	6505
Vector Product Format (VPF)	Demetra Voyadgis	6505

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Mission Areas	POC Name	DSN 328-XXXX
VPF Exploitation Software (VPFES)	Demetra Voyadgis	6505
VPF Statistics (VPFStat) Software	Demetra Voyadgis	6505
IN-VAL-ADD Software	Demetra Voyadgis	6505
Feature Foundation Data (FFD	Jeff Harrison	6505
Web Mapping	Jeff Harrison	6505
Military Symbology	Ken Brooker	6505
International Boundaries	Ken Brooker	6505
Geospatial Information Development Document and Specification Reviews	Ken Brooker	6505
Transportation Standard	Chris Berger	6505
Utilities Standard	Bill Blake	6505

INFORMATION SERVICES AND SUPPORT BRANCH

Aerial Photography Acquisition	Mary Pat Santoro	6909
Army Commercial Imagery Program	Mary Pat Santoro	6909
Department of State Liaison	Chris Schneider	6268
DTIC, NTIS Services	Peggy Diego	6657
Geospatial Information Library and Services	Don Morgan	6912
Geospatial Metadata	Peggy Clifton	6908
Intelink Services	Janice Johnson	6851
Intelligence Databases and Services	Wayne Washington	6913
Interlibrary loans	Peggy Diego	6657
Language Translation Services	Chris Schneider	6268
Map Cataloging	Peggy Clifton	6908
National Imagery Acquisition and Issues	Wayne Washington	6913
NIMA Data Sets	Connie Dutton	7425
Open Source Information System	Janice Johnson	6851
STINFO	Peggy Diego	6657
USGS Data Sets	Connie Dutton	7425
USGS EROS Data Center Liaison	Mary Pat Santoro	6909
USGS Mapping Center Liaison	Jon Sellin	9206
Web Services	Janice Johnson	6851

Digital Data Digest is now available in an electronic version. The newsletter will appear on the Internet at http://www.tec.army.mil beginning with the Spring 1999 issue. Paper copies will still be available.